REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
27-09-2018	Final Report	15-Oct-2017 - 14-Oct-2018

4. TITLE AND SUBTITLE

Final Report: Novel Permanent Magnets based on Nanowire Assemblies

5a. CONTRACT NUMBER
W911NF-17-1-0529

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
611102

6. AUTHORS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES

University of Texas at Arlington
701 South Nedderman Drive
Box 19145
Arlington, TX 76019 -0145

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES)

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSOR/MONITOR'S ACRONYM(S)
ARO

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
71164-MS.3

12. DISTRIBUTION AVAILIBILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Ping Liu
UU	UU	UU	UU		19b. TELEPHONE NUMBER 817-272-2815

RPPR Final Report
as of 02-Oct-2018

Agency Code:

Proposal Number: 71164MS **Agreement Number: W911NF-17-1-0529**
INVESTIGATOR(S):

Name: Ph.D Ping Liu
Email: pliu@uta.edu
Phone Number: 8172722815
Principal: Y

Organization: **University of Texas at Arlington**
Address: 701 South Nedderman Drive, Arlington, TX 760190145
Country: USA
DUNS Number: 064234610 EIN: 756000121
Report Date: 14-Jan-2019 Date Received: 27-Sep-2018
Final Report for Period Beginning 15-Oct-2017 and Ending 14-Oct-2018
Title: Novel Permanent Magnets based on Nanowire Assemblies
Begin Performance Period: 15-Oct-2017 **End Performance Period:** 14-Oct-2018
Report Term: 0-Other
Submitted By: Ph.D Ping Liu Email: pliu@uta.edu
Phone: (817) 272-2815
Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: **STEM Participants:**

Major Goals: This short-term project was aimed at understanding the proximity effect in ferromagnetic nanowire assemblies.

Accomplishments: See the technical report with details.

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: Faculty
Participant: J. Ping Liu
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Jeotikanta Mohapatra
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:

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as of 02-Oct-2018

National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Meiying Xing
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

ARTICLES:

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published
Journal: ACS Appl. Mater. Interfaces
Publication Identifier Type: Publication Identifier:
Volume: 2018 Issue: 10 First Page #: 27233
Date Submitted: 9/27/18 12:00AM Date Published: 7/23/18 5:00AM
Publication Location:
Article Title: Exchange coupling in soft magnetic nanostructures and its direct effect on their theranostic properties
Authors: Vikas Nandwana, Ruiying Zhou, Jeotikanta Mohapatra, Sungkyu Kim, Pottumarthi Prasad, J. Ping Liu, \
Keywords: magnetic nanostructures, exchange coupling, contrast enhancement, thermal activation, theranostics
Abstract: Exchange coupling between hard and soft magnetic materials at the nanoscale exhibits novel or improved physical properties for energy and data storageapplications. Recently, exchange coupling has also been explored in core/shell magnetic nanostructures (MNS) composed of hard and soft magnetic spinel ferrites, but applications have been limited in biomedicine due to the presence of “toxic” cobalt based ferrites as hard magnetic component. We report core/shell MNS where both core and shell components are soft magnetic ferrites (Fe3O4, MnFe2O4, and Zn0.2Mn0.8Fe2O4) and show that exchange coupling still exists due to the difference in their anisotropy. The physical properties (saturation magnetization, susceptibility, anisotropy, r2 relaxivity, and specific absorption rate) of core/shell MNS are compared with the same size single phase counterparts which excludes any size dependent effect and gives the direct effect of exchange coupling. After optimization of core and shell components and
Distribution Statement: 1-Approved for public release; distribution is unlimited.
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 02-Oct-2018

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published
Journal: Phys. Chem. Chem. Phys.
Publication Identifier Type: Publication Identifier:
Volume: 2018 Issue: 20 First Page #: 12879
Date Submitted: 9/27/18 12:00AM Date Published: 4/6/18 5:00AM
Publication Location:
Article Title: Size-dependent magnetic and inductive heating properties of Fe3O4 nanoparticles: Scaling laws across the superparamagnetic size
Authors: Jeotikanta Mohapatra, Zeng Fanhao, Kevin Elkins, Meiying Xing, Madhav Ghimire, Sunghyun Yoon, Sa
Keywords: nanoparticles, size distribution, hyperthermia
Abstract: An efficient heat activating mediator with an enhanced specific absorption rate (SAR) value is attained via control of the iron oxide (Fe3O4) nanoparticle size from 3 to 32 nm. Monodispersed Fe3O4 nanoparticles are synthesized via a seed-less thermolysis technique using oleylamine and oleic acid as the multifunctionalizing agents (surfactant, solvent and reducing agent). The inductive heating properties asa function of particle size reveal a strong increase in the SAR values with increasing particle size up to 28 nm. In particular, the SAR values of ferromagnetic nanoparticles (416 nm) are strongly enhanced with the increase of ac magnetic field amplitude than that for the superparamagnetic (3–16 nm) nanoparticles. The enhanced SAR values in the ferromagnetic regime are attributed to the synergistic contribution from the hysteresis and susceptibility loss. Specifically, the 28 nm Fe3O4 nanoparticles exhibit an enhanced SAR value of 801 W g¬1 which is nearly an order higher than that o
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Acknowledged Federal Support: **Y**

Final Technical report:

Effects of packing density on the magnetic properties of cobalt nanowire assemblies

1. Introduction

During the last decade, a significant research effort has been given to the synthesis and characterization of magnetic nanowires (NWs), particularly the single-crystal hcp-structured Co NWs. Co NWs with the aspect ratio from 10 to 66 have been synthesized via a solvothermal method by controlling the growth process (Fig.1). The increased aspect ratio leads to enhanced coercivity of the nanowire assemblies up to an optimum value of 12.5 kOe at 300 K, which is close to the theoretical limit of the coercive field (14.3 kOe). To realize a permanent magnet made from the high coercivity nanowires, the effect of packing density on the magnetic properties need to be explored in detail, which is of a fundamental importance to the understanding of nanostructured magnetic materials.

2. Description of the research work

In the past year we have prepared Co NW assemblies with packing densities varying from 2.1 to 6.5 g/cm^3, using the as-prepared Co NWs with coercivity (*Hc*) about 5.5 kOe. The corresponding *Hc* at room temperature increases from 5.5 kOe to 6.1 kOe with the increase in packing density from 2.1 to 4.5 g/cm^3, and the *Hc* decreases while the packing density further increases. A similar trend in the *Hc* value has also been found at different temperatures as shown in Figure 2. Moreover, the remanence (*Mr*) increased from 72.0 to 82.5 emu/g with the increased packing density. The initial increase in Hc and *Mr* values may be due to enhanced magnetostatics interactions between the nanowires upon increased packing density. However, above the density of 4.5 g/cm^3, the *Hc* decreases possibly due to the proximity effect as it has been noticed in the δM plot. The δM plot shows a negative peak at high field and it becomes prominent with the increase of density (Figure 3).

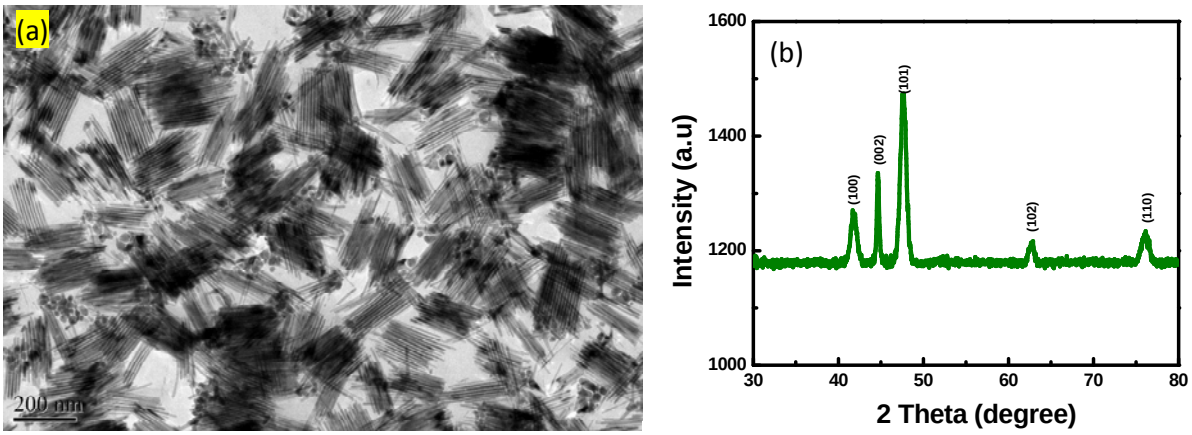

Figure 1: (a) TEM image and (b) XRD pattern of Co nanowires. Figure 1a shows the Co nanowires are cylinder shapes of typical size about 100 to 180 nm in length and an average diameter of 10 nm. X-ray diffraction shows that the wires have an expected hcp crystal structure.

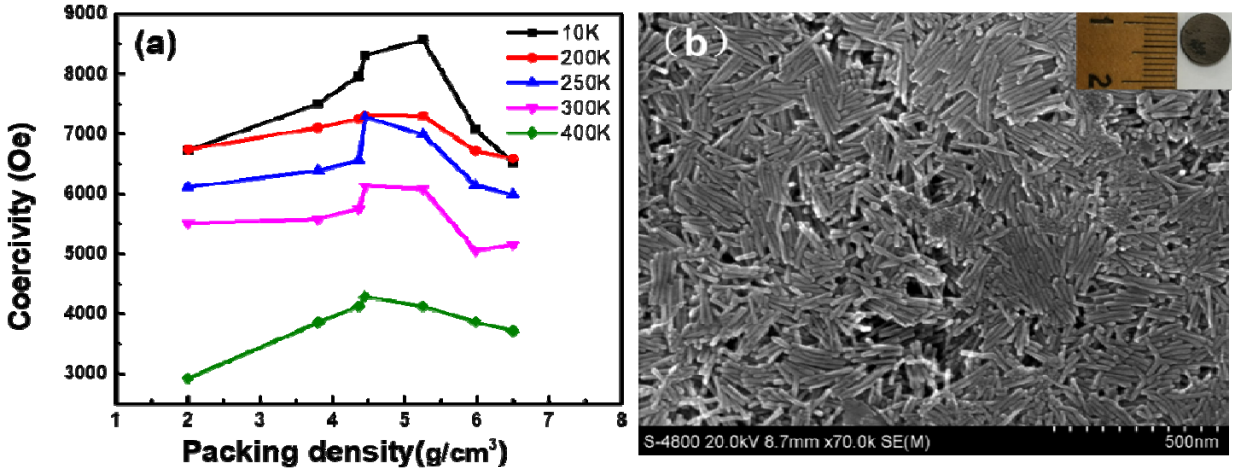

Figure 2. (a) Packing density dependence of coercivity at different temperature. Figure 1. (b) SEM image of the Co NWs assemblies. The inset image is the Co NWs assembly pellet.

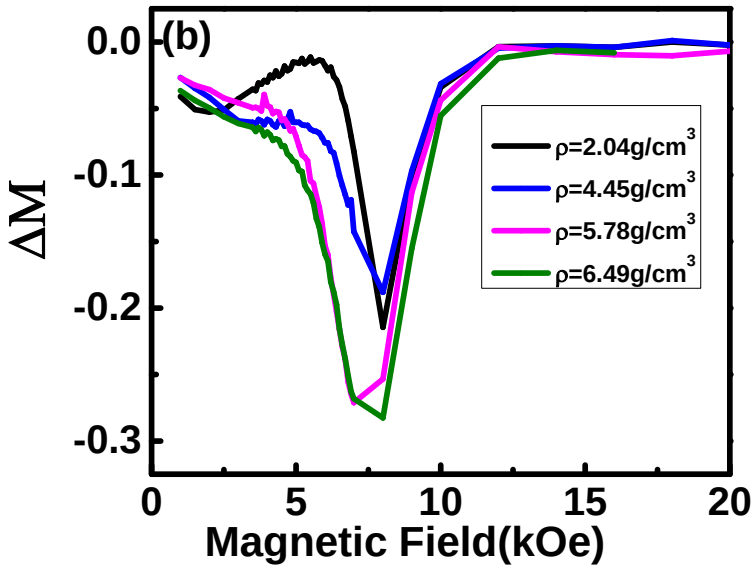

Figure 3. (a) Delta M of compacted Co NWs assemblies with different packing densities.

3. Publications

1. Vikas Nandwana, Ruiying Zhou, Jeotikanta Mohapatra, Sungkyu Kim, Pottumarthi Prasad, J. Ping Liu, Vinayak Dravid, *Exchange coupling in soft magnetic nanostructures and its direct effect on their theranostic properties*, ***ACS Appl. Mater. Interfaces,*** 10 (32), pp 27233–27243, **2018**.

2.Jeotikanta Mohapatra, Zeng Fanhao, Kevin Elkins, Meiying Xing, Madhav Ghimire, Sunghyun Yoon, Sanjay R Mishra, J. Ping Liu, *Size-dependent magnetic and inductive heating properties of Fe3O4 nanoparticles: Scaling laws across the superparamagnetic size*, ***Phys. Chem. Chem. Phys.,*** **2018**, 20, 12879-12887.

3. Meiying Xing, Jeotikanta Mohapatra, and J. Ping Liu, Effect of packing density on magnetic properties of Co nanowire assemblies, in preparation.